Zn ABUNDANCE IN COEXISTING TROILITE AND SPINEL IN ACHONDRITES: REMNANT INDICATIVE OF THE PRIMITIVE SOURCE MATERIALS. J. Chikami[1], H. Takeda[2], K. Yugami[1], T. Mikouchi[1], and M. Miyamoto[1], [1]Mineralogical Institute, Graduate School of Science, University of Tokyo, Hongo, Tokyo 113, Japan, chikami@min.s.u-tokyo.ac.jp, [2]Chiba Institute of Technology, 2-17-1, Tsudanuma, Narashino City, Chiba 275, Japan.

Introduction: Zn is a volatile chalcophile element such as Cd, Se, Te, etc. Cowley [1] noted that meteorites contain 115 ppm Zn in metal, 1530 ppm in sulfides, 76 ppm in silicates and that ore melts contain 8 ppm Zn in metal, 16800 ppm in sulfides, 3700 ppm in silicates. Therefore, Zn is chalcophile in behavior. The geochemistry of Zn is mainly interpreted by the similarity in ionic radii between divalent Zn and the cations of the magnesium-iron group, especially between Zn and Fe [2].

It has been known that chondrites have significant Zn content in their silicate grains, while achondrites do not contain Zn [3].

We have studied behavior of Zn between spinel and troilite in primitive achondrites (ALH78230, Y791491, Caddo County), eucrites (A881388, A881374, Y790447, Y75210) and diogenite (Y74013) by analyzing with an electron microanalyzer (EPMA) in order to understand the formation processes of spinel and troilite in these meteorites.

Primitive Achondrites: ALH78230 is an acapulcoite [4] and consists of orthopyroxene, augite, olivine, plagioclase and metal. The chemical composition of troilites in ALH78230 is Fe 63 wt%, S 36 wt%. These troilites (coexisting with chromites, FeNi metal, silicates) contain Zn under detection limit. FeNi metal contains Fe 93 wt% and Ni 7 wt%. Chromites (coexisting with troilites, FeNi metal, silicates) in ALH78230 ($Chr_{80}Hy_{14}Ulv_6$) contain 1.0–1.5 wt% of ZnO content.

The Y791491 lodranite contains major coarse-grained orthopyroxene and olivine, variable amounts of FeNi metal and troilite, and minor plagioclase [5]. FeNi metal (Fe 93 wt%, Ni 7 wt%) and troilites (coexisting with metal and silicates) in Y791491 contain Zn under detection limit. Chromites coexisting with metal and silicate ($Chr_{83}Hy_{12}Ulv_5$) contain ZnO 0.6 wt%.

Silicate inclusion in the Caddo County IAB iron meteorite [5] contains chromite grain coexisting with troilite and metal with chemical composition of $Chr_{93}Hy_4Ulv_3$. This chromite grain contains the highest ZnO content (2 wt%) among samples we studied in this paper. Troilite and metal (Fe 94 wt%, Ni 5.5 wt%) contain Zn under detection limit.

Eucrites: A881388, an unbrecciated non-cumulate eucrite consists of equigranular pigeonites, augite, plagioclase, and minor minerals [6]. Troilites coexisting with spinel in A881388 contain Zn under detection limit. The chemical composition of FeNi metal coexisting with spinel is Fe 99.3 wt% and Ni 0.02 wt%. We found that coexisting ilmenite (TiO_2 54 wt%, FeO 45 wt%) and chromite ($Chr_{72}Hy_{14}Ulv_{44}$) contain Zn under detection limit.

Cumulate eucrite A881394 is depleted in volatile elements, and is possibly metamorphosed products [7]. A881394 contains troilites and chromites ($Chr_{64}Hy_{17}Ulv_{19}$) which contain Zn under detection limit.

The Y790447 eucrite is proposed to be once melted and its pyroxene contains the remnant of Mg-rich core. It contains coexisting ilmenites (TiO_2 54 wt%, FeO 43 wt%, MgO 2.5 wt%) and chromites ($Chr_{47}Hy_{10}Ulv_{43}$). Spinels contain Zn content under detection limit.

Y75210 is a monomict eucrite of the highest metamorphic grade [8] and often includes pigeonite in granoblastic pyroxene (GP) areas, which consist of fine-grained transparent polygonal grains of augite [9]. Zn content of coexisting ilmenite (TiO_2 52.5 wt%, FeO 45 wt%) and chromite ($Chr_{67}Hy_{16}Ulv_{17}$) in GP areas of Y75210 is under detection limit and is the Zn content of coexisting ilmenite and troilite as well.

Diogenite: Y74013 shows a fine granoblastic recrystallized texture, primarily of orthopyroxene. Chromites occur as large isolated clots up to 5 mm in diameter and are subrounded [10], suggesting that they are initial cumulate chromite from a magma. Zn content of chromites ($Chr_{81}Hy_{15}Ulv_4$) is under detection limit. Troilites enclosed in the chromite do not contain detectable Zn.

Discussion: It has been known that Cr-rich spinels from carbonaceous chondrites generally have ZnO above the detection limit of EPMA, and that up to 2–3 wt% ZnO can be concentrated in chromite in the L and LL chondrites. Johnson and Prinz [11] reported that among CO3 carbonaceous chondrites, ALH77307 (3.0) and Kainsaz (3.1) have ZnO below the detection limit of 0.04 wt%, whereas Ornans (3.3) and Warrenton (3.6) chromites contain 0.1–0.3 wt% ZnO. Similarly, non-reequilibrated chromites in Semarkona have Zn below detection, whereas virtually all other chromites in LL and L chondrites of high petrographic type contain >0.1 wt% ZnO. They suggested that the high Zn contents may result from reequilibration of the chromites, possibly with troilite in which sphalerite has a small but sufficient solubility. Y74160, shock recrystallized LL7 chondrite retain CI level bulk Zn concentration, whereas other volatile, chalcophile elements are depleted. The Y74160 chromite is a reservior of Zn [12].

Kracher [13] found euhedral chromites in sulfides or metal in IAB silicate inclusions, with the chromites having crystallized under reducing conditions from a sulfide melt containing chalcophile Cr, Mn and Zn. Chromites in Y74025 and Y75305 (winonites) may have also crystallized from a sulfide-metal liquid under reducing conditions, suggesting that sulfide-metal fractions of the winonites, once melted [14]. Our data (ALH78230, Y791491, Caddo County) also show the same trends in that spinels contain significant Zn, while troilites coexisting with spinels contain Zn under detection limit. We compared Zn content in spinels with that of bulk composition, and found that almost half of the bulk Zn contents of the entire meteorite (Acapulco) is retained in chromites (modal abundance, 1.3 wt%) [15]. This fact suggests that Zn would be retained preferentially in the spinel structure because Zn-Fe spinel is a stable compound even at high temperatue [16].

Spinels in diogenite contain Zn under detection limt, although Delaney (personal comm.) suggested that formation of high-temperature cumulate chromite would isolate the Zn from the sulfide that would normally take it. The differentiated meteorites such as eucrites would have crystallized from molten magmas that are normally depleted in volatile elements such as Zn and Na. The eucrites investigated by us have been proposed to be a recrystallized products of pristine lavas, which are partial melt of the chondritic source materials. The very low contents of Zn in these lavas cast some doubt about their primitive partial melt.

Conclusions: Spinels in primitive achondrites have significant Zn content, while troilites do not contain Zn. Differentiated achondrite (eucrite and diogenite) do not contain Zn. This fact would suggest that Zn is preferentially retained in spinel structure, not in troilite and that Zn is depleted with other volatile element such as Na before crystallization of spinels in eucrite and diogenite.

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